L. M. Haupt
May 1, 07

"HOFFMAN"
ROSENDALE
CEMENT,
MANUFACTURED BY THE
LAWRENCE CEMENT CO.
OFFICE, 67 WILLIAM ST., COR. CEDAR,
NEW YORK.

ROSENDALE CEMENT,

ITS USES AND MODE OF APPLICATION,

TOGETHER WITH

REPORT OF THE COMMITTEE

OF

"AMERICAN SOCIETY OF CIVIL ENGINEERS"

ON A

UNIFORM SYSTEM FOR TESTS OF CEMENT.

LAWRENCE CEMENT COMPANY,
OFFICE, 67 WILLIAM ST., COR. CEDAR,
NEW YORK.

ROSENDALE CEMENT.

FORMULAS AND DIRECTIONS FOR ITS USE,

COMPILED AND ARRANGED BY

LUDLOW V. CLARK, JR.

PRESENTED BY

LAWRENCE CEMENT COMPANY

MANUFACTURERS OF THE

"HOFFMAN" ROSENDALE CEMENT,

67 William Street, New York.

1891.

ROSENDALE CEMENT.

Rosendale Cement was first discovered in Rosendale, Ulster County, New York, in the year 1823, during the construction of the locks and other masonry of the Delaware and Hudson Canal, which passes through that county. Its production has gradually increased until there are now made from two millions to two and a half million barrels in each season of about eight to nine months, or during the period of navigation on the Hudson River between Rondout and New York.

Rosendale Cement is made from a hard, fine-grained stone, of a dark blue color. The stone is quarried by blasting with high explosives. It is then broken into pieces of a suitable size, mixed with fine anthracite coal, and burned in kilns especially constructed for that purpose. After the stone has been properly burned, it is drawn from the kilns, allowed to cool, then taken to the mills to be finely ground and prepared for market.

The "Hoffman" Cement, as made by the Lawrence Cement Co., has been before the public for nearly sixty years. It is very uniform in quality, and for use in all kinds of work, where a good cement is needed, the reliability and general fitness of this brand of cement cannot be fairly questioned. When properly used, the results are certain.

USES OF "HOFFMAN" CEMENT.

"Hoffman" Cement has been used in every character of work, both above and under water, with the most marked success.

In Sewers and Drains.—All underground structures are ordinarily subjected to the continuously destructive influence of gases, water and moisture. But "Hoffman" Cement grows stronger under these influences, and therefore is peculiarly adapted to this class of work. The sewers and other costly subterraneous structures of ancient cities, built with cement, have stood the test of centuries, increasing in strength with the lapse of time. In all parts of the world at the present time, cement, and cement with sand, are the principal materials used in this class of work. Usually other materials in sewers, especially brick, should be thoroughly covered with cement as a protection from the corroding effects of moisture. The theory sometimes advanced, that *good cement* may be injured by the ordinary acids of sewage is without foundation in science or human experience.

In Street Pavement.—The problem of durable street pavement has probably received more attention, and cost more money in experimenting, than any other presented to the engineer. Block and asphalt pavements have been, and are now being, extensively laid, and cement concrete has been found to be the cheapest and most durable foundation. In block pavements the fact of the foundation being distinct from the material with which it is covered, eliminates the expense of a new foundation when repairs or reconstruction of streets is necessary. The longer it remains, the harder it gets; being perfectly impervious to water, the blocks are always kept at the same grade, and the street must wear off at the top to become uneven.

Asphalt is laid on a foundation of six inches of hydraulic cement concrete, and a wearing surface of bituminous mastic (Trinidad asphalt, petroleum, oil and sand), laid in two coats, respectively a half-inch and two inches thick when compressed. The theory of this pavement is a solid base of concrete masonry, practically imperishable, and a comparatively thin and smooth wearing surface, that can be replaced when it is worn out.

GENERAL USES.

In addition to its use for abutments and piers of bridges and the walls of heavy buildings, it is adapted for—

- Concrete for foundations for heavy structures.
- Concrete for foundations for wharves.
- For breakwater and harbor work.
- Floors for breweries, malt-houses, distilleries, ice-houses, green-houses and bath-houses.
- Floors for railway round-houses and car-shops.
- Floors for cellars and stables.
- Reservoirs, gas and water-tanks.
- Mill-dams and aqueduct work.
- For laying tile and marble floors.
- Cement drain pipe
- Floors and cells for jails and prisons.
- Kitchen hearths, etc., etc.

HOW TO USE "HOFFMAN" ROSENDALE CEMENT.

Concrete.

"Hoffman" Cement is especially adapted to the making of concrete. It can be relied upon with implicit confidence to attain great strength, be perfectly uniform, and grow harder year after year, the older it gets. But the sand, gravel and stone must be clean and hard, and the wetting, mixing and depositing be perfectly done.

PROPORTIONS.

The following proportions for mixing concrete have been found suitable for most purposes where concrete is used, but depend somewhat on the quality of the sand and the size of the stone used —

A 1 part Rosendale Cement, 2 parts sand, 3 parts gravel, 4 parts chips.

B 1 part Rosendale Cement, 2 parts sand, 4 parts chips.

C 2 parts Rosendale Cement, 2 parts sand, 7 parts broken trap rock.

MIXING.

The details of mixing by hand are different with nearly every concrete maker, but from long experience we would recommend the following system: Boards about twelve feet long should be laid on flat ground as near the place of deposit as possible; other boards should be stood upon edge, held by stakes driven into the ground, dividing the board floor into spaces about six feet wide. With three such places, ten men can mix forty cubic yards per day, two men mixing the sand and cement in the centre space, and four men at each side alternately mixing the wet sand and cement with the stone. The sand is first measured by wheelbarrow loads into the centre space and spread; over that is spread the equivalent of cement, say one-half a barrel of cement to two railroad wheelbarrow loads of sand, one part cement to two parts of sand. The sand and cement are then turned four times dry or until thoroughly mixed. Then water enough is added by means of a fine sprinkler (when possible) to make the mixture hold its form when pressed in the hand. The stone, meantime, having been spread in one

---

A Used in these proportions for foundations by the officers of the Engineer Corps U. S. Army.

B The formula used by many architects and by the engineers of the East River Bridge.

C Used in the construction of the foundation mass of the pedestal of the Statue of Liberty. Careful tests made for crushing strength by General C. P. Stone, put the breaking weight per square foot as follows: Six months, $58\frac{53}{100}$ tons; twenty-seven months, $97\frac{52}{100}$ tons; twenty-eight months, $104\frac{24}{100}$ tons.

of the side spaces, say four railroad wheelbarrow loads, it having been previously, on the barrows or elsewhere, been wet, and the excess of water allowed to drain off. The sand and cement is spread over it and turned four times, then wheeled and deposited where wanted. Rammers are used to pound it into place. If well pounded the water should appear slightly on the surface. The mixture must not be allowed to come in contact with the bare ground before being deposited.

* Too much water renders the concrete porous and weak, and tends to separate the cement from the sand. It is a common fault, and requires constant effort to keep common laborers from adding too much water.

DEPOSITING.

The concrete, as soon as thoroughly mixed, and while still fresh, should be carefully deposited and rammed until dense, but not hard enough to break the stone, or continued long enough to injure the setting. The surface of each layer should be made as rough as possible to insure a good body with the next. It is much better if a short time only intervenes between depositing adjoining layers—that, is before the lower one has set, thereby making a stronger bond. The concrete should be gently slid or shoveled into place. If placed against brick or other porous walls, the latter should be first thoroughly wet.

GROUT.

Grout is merely common mortar made so thin as to flow almost like cream. It is intended to fill interstices left in the mortar joints of rough masonry; but, unless it contains a large amount of cement, it is probably worthless. We recommend one part cement to one part sand.

* An excess of water weakens either cement, mortar or concrete.—*Grant*.

MORTAR.

In mixing mortar of cement and sand, always thoroughly mix the cement and sand dry, and then add water, by sprinkling, when possible, sufficient to make the mortar trowel easily. Work the mix until water flushes to the surface. Do not mix more mortar at a time than can be used in the work without tempering, or adding more water.

PLASTERING MORTAR.—One part cement and one part sand, thoroughly mixed. Joints should be deeply cut out and washed out with water. Keep edges wet and face damp until finished. Lay on three-quarters to one inch thick.

POINTING MORTAR.—One part cement and one part sand thoroughly troweled.

CISTERN LINING.—Two parts cement and one part sand.

FOR BRICK AND STONE WORK.—One part cement and one part sand makes the best work, although one part cement to two parts sand is used with good results. Bricks should always be wet, or soaked in water, before being laid in cement; if not, they absorb the water from the mortar, and injure its setting properties.

SAND.

The common specification of clean, coarse, sharp sand is the best brief description of the proper sand to be used. Sand that has slate and limestone and other mineral particles that are weaker than the cement, is injurious to good work, and with it it is impossible to make concrete or mortar of the best quality. The strength of concrete or mortar is weakened by using fine sand, but not by using coarse, unless it is quite coarse. Very fine sand should never be used; if the sand is any finer than that passing through a sieve with thirty meshes to the lineal inch, it should be mixed with a large proportion of coarser. The sand should be clean, either washed by nature or artificially. Sand with round corners and polished surfaces should be avoided. The more angular and rough the better. Too much care cannot be taken to obtain clean, sharp, hard, coarse sand. The qualities which are desirable in sand, except size, apply to gravel or crushed stone.

TABLE,

Showing Quantities of Excavation, Stone and Brick Lining and Plastering, in Cisterns of Various Diameters, for Each Foot of Depth. Also, Number of Bricks and Amount of Plastering in Bottom

Diameter in Feet	For this Column Use Diameter of Digging.	FOR EACH FOOT OF DEPTH. For These Columns Use Diameter in Clear of Lining			BOTTOM.	
					Bricks in Bottom.	Plastering in Bottom
	Cubic Yards of Digging.	Stone Lining one foot thick, Perches of 25 Cubic Feet.	Number of Bricks in Lining—one Thick.	Square Yards Plastering.	Use Diameter of Digging.	Use Diameter in clear of Lining
1	.02	.25	48	.35	6	.08
2	.12	.38	95	.70	24	.35
3	.26	.50	140	1.05	54	.78
4	.46	.63	185	1.39	95	1.39
5	.73	.75	230	1.74	148	2.18
6	1.04	.88	275	2.09	215	3.14
7	1.42	1.00	320	2.44	292	4.27
8	1.86	1.13	365	2.79	382	5.58
9	2.36	1.26	410	3.14	483	7.06
10	2.91	1.38	460	3.49	596	8.72
11	3.52	1.51	500	3.84	722	10.56
12	4.19	1.63	550	4.19	859	12.56
13	4.92	1.76	590	4.54	1,008	14.74
14	5.70	1.88	640	4.89	1,170	17.10
15	6.54	2.01	680	5.24	1,343	19.63
16	7.45	2.14	730	5.58	1,527	22.34
17	8.40	2.26	770	5.93	1,725	25.22
18	9.42	2.39	820	6.28	1,934	28.27
19	10.50	2.51	860	6.63	2,154	31.50
20	11.64	2.64	910	6.98	2,388	34.90
21	12.83	2.76	950	7.33	2,632	38.48
22	14.08	2.89	1,000	7.68	2,888	42.23
23	15.39	3.02	1,040	8.03	3,157	46.16
24	16.76	3.14	1,090	8.38	3,438	50.26
25	18.18	3.27	1,130	8.73	3,730	54.54

CAPACITY OF CISTERNS.

In U. S. Gallons, for each Ten Inches in Depth

Diameter, Feet	Gallons.	Diameter, Feet	Gallons	Diameter, Feet	Gallons
2	19	8	314	14	960
3	44	9	397	15	1,102
4	78	10	489	20	1,958
5	122	11	592	25	3,060
6	176	12	705	. . . . . .	. . . . .
7	240	13	827	. . . . . .	. . . . .

CEMENT PLASTER.

CAPACITY OF ONE BUSHEL OF CEMENT IN PLASTERING.	THICKNESS. 1 Inch.	¾ Inch.	½ Inch
	Yards.	Yards	Yards
1 bushel of Cement will cover	1¼	1½	2¼
1 " " and 1 of sand covers . .	2¼	3	4½
1 " " " 2 " " . .	3½	4½	6¾

(From Louisville Pamphlet).

TESTIMONIALS OF "HOFFMAN" CEMENT.

"Hoffman" Cement has been used extensively at the Navy Yard at Brooklyn, L. I.; Norfolk, Va.; San Francisco, Cal.; and the following forts were built with the "Hoffman" Cement:—

Fort "Delaware."
" "Jackson."
" "Sumpter."
" "Taylor."
" "Jefferson."
" "Hamilton."
" at Amelia Island.
" at Garden Keys.
" "Knox."
" at Governor's Island, N. Y. Harbor.
" at Pensacola, Fla.
" at San Francisco, Cal.
" "Montgomery."
" "Adams."
" "Trumbull."
"Fortress Monroe."

20,000 bbls. were used on the Capitol, at Washington. 10,000 bbls., Washington Water Works. It was also used for building the Patent Office, Treasury Building, and other buildings at Washington.

PENNSYLVANIA RAILROAD.

Over 35,000 bbls. "Hoffman" Cement used by the Maintenance of Way Department during the past five years.

NEW YORK, September 1, 1834.

The subscriber, having been employed as a workman on the foundations of the Custom House, now being erected in the City of New York, testifies, that having been directed by Mr. Samuel Thompson, the Superintendent, to enlarge an opening in the said foundation, in doing which it became necessary to cut away a part of the stone work which had been laid in "*Hoffman Cement*" since the month of June last past; it had acquired more hardness and tenacity than any stone work I ever had occasion to remove, being nearly equal to the same mass of solid rock. I will further state that in my vocation I have removed stone work in Europe that had stood upwards of two hundred years, and constructed of such as were considered the best materials; but, as above stated, I

have never met with any wall of equal hardness and solidity. I therefore recommend the said cement as greatly superior to any other material I have met with for laying every description of stone or brick work.

PETER CUSACK.

I approve the above recommendation.

EDWARD COOK, *Foreman.*

I approve of the above certificate of Peter Cusack, and add my testimonial thereto.

SAMUEL THOMSON, *Superintendent.*

DRY DOCK OFFICE, U. S. NAVY YARD,
BROOKLYN, L. I., October 1, 1849.

Sir:—I take the liberty to write to you on the subject of the use of cement. I have used some 12,000 barrels, which has been of remarkable excellence, not one of the barrels being found defective or unable to bear the rigid test.

The Lawrence Company stand very high as manufacturers of this article, and pride themselves upon a reputation of never sending a poor barrel to anyone.

Respectfully, your obedient servant,

WM. J. MCALPINE, *Engineer.*

OFFICE OF H. A. DWIGHT,
ALBANY, N. Y., June 17, 1882.

LAWRENCE CEMENT CO.—

Gents:—I have used the "Hoffman Rosendale Cement" the past twenty-two years; have also used various other brands; but have found no Rosendale Cement that gives the universal satisfaction which the "Hoffman" does. In all my experience I have never had a barrel of the "Hoffman" Cement returned on account of its poor quality. Am now selling largely, and all of my orders call for the "Hoffman Rosendale Cement."

Yours truly, H. A. DWIGHT.

R. T. PRENTISS, *Commission Merchant,*
HOLYOKE, MASS., July 29, 1882.

LAWRENCE CEMENT CO.—

Gentlemen:—I have sold thousands of barrels of the old "Hoffman" Cement during the last ten years; have a larger trade in it to-day than ever before, and many of my customers will use nothing else. In short, I consider it the best cement in the market. Will send for more in a day or two.

Yours respectfully, R. T. PRENTISS.

WHEELER & HOWES, *Dealers in Coal, etc.*,
BRIDGEPORT, CONN., Sept. 28, 1882.

LAWRENCE CEMENT CO.—

Dear Sirs:—We have sold the "Hoffman" Cement for the last fifteen years, as your books will show, and it has given universal satisfaction; in fact, we have not had occasion in even a single instance, to find fault with either the quality of the cement or the packages. Should you see fit at any time to refer to us, we should take pleasure in recommending your cement.

We remain, yours respectfully, WHEELER & HOWES.

CITY ENGINEER'S OFFICE, NO. 11 CITY HALL.
WORCESTER, MASS., October 1, 1883.

I hereby certify that the City of Worcester has used the "Hoffman" brand of cement, for the past season on all its public works, and it gives me great pleasure to state that the cement has been perfectly satisfactory in every respect.

C. A. ALLEN, *City Engineer.*

SCRANTON, PA., Nov. 4, 1890.

LAWRENCE CEMENT CO.—

Gentlemen:—I take pleasure in giving my testimony in favor of your "Hoffman" brand Rosendale Cement. I have sold it in my general trade for five years or more, and find that it gives universal satisfaction. There was a large amount used in finishing the large reservoir of the Scranton Gas and Water Company, at Dunning, Pa., where it gave entire satisfaction under a severe test by Mr. Gould, the engineer.

Very truly yours, LUTHER KELLER.

PHILADELPHIA, PA., Jan. 10, 1891.

LAWRENCE CEMENT CO.—

505 Chestnut street, Philadelphia, Pa.

Gentlemen:—In answer to your inquiry, we have to say that we have used "Hoffman" Cement extensively in heavy bridge masonry for the last six years and it has given universal satisfaction.

Very truly yours, SPARKS & EVANS.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

127 E. Twenty-third Street.

TRANSACTIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

315.

(Vol. XIV.—November, 1885.)

REPORT OF THE COMMITTEE ON A UNIFORM SYSTEM FOR TESTS OF CEMENT.

PRESENTED AT THE ANNUAL MEETING, JANUARY 21, 1885.

To the American Society of Civil Engineers:—

Your Committee, appointed to devise a uniform system for tests of hydraulic cement, has the honor to submit this final report. Those portions of the preliminary report presented at the Annual Meeting, held January 16, 1884, which are not embodied herein, are superseded.

A uniform system of testing cement, in order to be practical, must be simple, rapid and easy of application, and should, of course, be reasonably accurate. Between the very careful tests of the laboratory, which consume much time and involve considerable expense, and the rough and unsatisfactory trials often resorted to from necessity, there is a middle ground, which it has been the endeavor of the Committee to occupy. The system proposed is by no means a perfect one—such has not yet been discovered—but it is hoped that it will be useful in eliminating many of the inaccuracies of the usual methods, and by making the system uniform, enable the experiments of the various members of the profession, in different parts of the country, and others interested in the subject of cement testing, to be satisfactorily compared.

The testing of cement is not so simple a process as it is sometimes thought to be. No small degree of experience is necessary before one can manipulate the materials so as to obtain even approximately accurate results.

The first tests of inexperienced, though intelligent and careful persons, are usually very contradictory and inaccurate, and no amount of experience can eliminate the variations introduced by the personal equations of the most conscientious observers. Many things, apparently of minor importance, exert such a marked influence upon the results, that it is only by the greatest care in every particular, aided by experience and intelligence, that trustworthy tests can be made.

The test for tensile strength on a sectional area of one square inch is recommended, because, all things considered, it seems best for general use. In the small briquette there is less danger of air bubbles, the amount of material to be handled is smaller, and the machine for breaking may be lighter and less costly.

The tensile test, if properly made, is a good, though not a perfect, indication of the value of a cement. The time requisite for making this test, whether applied to either the natural * or the Portland cements, is considerable (at least seven days, if a reasonably reliable indication is to be obtained), and, as work is usually carried on, is frequently impracticable. For this reason short-time tests are allowable in cases of necessity, though the most that can be done in such testing is to determine if the brand of cement is of its average quality. It is believed, however, that if a neat cement stands the one-day tensile test, and the tests for checking and for fineness, its safety for use will be sufficiently indicated in the case of a brand of good reputation; for, it being proved to be of average quality, it is fair to suppose that its subsequent condition will be what former experiments, to which it owes its reputation, indicate that it should be. It cannot be said that a new and untried cement will, by the same tests, be proved to be satisfactory; only a series of tests for a considerable period, and with a full dose of sand, will show the full value of any cement; and it would be safer to use a trustworthy brand without applying any tests whatever, than to accept a new article which had been tested only as neat cement, and for but one day.

The test for compressive strength is a very valuable one in point of fact, but the appliances for crushing are usually somewhat cumbersome and expensive, so much so that it seems undesirable that both tests should be embodied in a uniform method proposed for general adoption.

* Where the word natural is used in this connection, it is to be understood as being applied to the lightly-burned natural American or foreign cements, in contradistinction to the more heavily-burned Portland cement, either natural or artificial.

Where great interests are at stake, however, and large contracts for cement depend on the decision of an engineer as to quality, both tests should be used if the requisite appliances for making them are within reach. After the tensile strength has been obtained, the ends of the broken briquettes, reduced to one-inch cubes by grinding and rubbing, should be used to obtain the compressive strength.

The adhesive test being in a large measure variable and uncertain, and therefore untrustworthy, is not recommended.

Fineness.

The strength of a cement depends greatly upon the fineness to which it is ground, especially when mixed with a large dose of sand. It is, therefore, recommended that the tests be made with cement that has passed through a No. 100 sieve (10,000 meshes to the square inch), made of No. 40 wire, Stubbs' wire gauge. The results thus obtained will indicate the grade which the cement can attain, under the condition that it is finely ground, but it does not show whether or not a given cement offered for sale shall be accepted and used. The determination of this question requires that the tests should also be applied to the cement as found in the market. Its quality may be so high that it will stand the tests even if very coarse and granular, and, on the other hand, it may be so low that no amount of pulverization can redeem it. In other words, fineness is no sure indication of the value of a cement, although all cements are improved by fine grinding. Cement of the better grades is now usually ground so fine that only from 5 to 10 per cent. is rejected by a sieve of 2,500 meshes per square inch, and it has been made so fine that only from 3 to 10 per cent. is rejected by a sieve of 32,000 meshes per square inch. The finer the cement, if otherwise good, the larger dose of sand it will take, and the greater its value.

Checking or Cracking.

The test for checking or cracking is an important one, and, though simple, should never be omitted. It is as follows:—

Make two cakes of neat cement 2 or 3 inches in diameter, about ½ inch thick, with thin edges. Note the time in minutes that these cakes, when mixed with water to the consistency of a stiff plastic mortar, take to set hard enough to stand the wire test recommended by Gen. Gilmore, $\frac{1}{12}$ inch diameter wire loaded with ¼ of a pound, and $\frac{1}{24}$ inch loaded with 1 pound. One of these cakes, when hard enough, should be put in water and examined from day to day to see if it becomes contorted, or if cracks show themselves at the edges, such contortions or cracks indicating that the cement is unfit for use at that

time. In some cases the tendency to crack, if caused by the presence of too much unslacked lime, will disappear with age. The remaining cake should be kept in the air and its color observed, which for a good cement should be uniform throughout, yellowish blotches indicating a poor quality; the Portland cements being of a bluish-gray, and the natural cements being light or dark, according to the character of the rock of which they are made. The color of the cements when left in the air indicates the quality much better than when they are put in water.

Tests Recommended.

It is recommended that tests for hydraulic cement be confined to methods for determining fineness, liability to checking or cracking, and tensile strength; and for the latter, for tests of 7 days and upward, that a mixture of 1 part cement to 1 part of sand, for natural cements, and 3 parts of sand for Portland cements, be used in addition to trials of the neat cement. The quantities used in the mixture should be determined by weight.

The tests should be applied to the cements as offered for sale. If satisfactory results are obtained with a full dose of sand, the trials need go no further. If not, the coarser particles should first be excluded by using a No. 100 sieve, in order to determine approximately the grade the cement would take if ground fine, for fineness is always attainable, while inherent merit may not be.

Note.—Your committee thinks it useful to insert here a table showing the average minimum and maximum tensile strength per square inch which some good cements have attained when tested under the conditions specified elsewhere in this report. Within the limits given in the following table, the value of a cement varies closely with the tensile strength when tested with the full dose of sand.

American natural cement, neat:—

1 day, 1 hour or until set, in air, the rest of the 24 hours in water, from 40 pounds to 80 pounds.

1 week, 1 day in air, 6 days in water, from 60 pounds to 100 pounds.

1 month (28 days), 1 day in air, 27 days in water, from 100 pounds to 150 pounds.

1 year, 1 day in air, the remainder in water, from 300 pounds to 400 pounds.

American and foreign Portland cements, neat:—

1 day, 1 hour, or until set, in air, the rest of the 24 hours in water, from 100 pounds to 140 pounds.

1 week, 1 day in air, 6 days in water, from 250 pounds to 550 pounds.

1 month (28 days), 1 day in air, 27 days in water, from 350 pounds to 700 pounds.

1 year, 1 day in air, the remainder in water, from 450 pounds to 800 pounds.

Mixing, etc.

The proportions of cement, sand and water should be carefully determined by weight, the sand and cement mixed dry, and all the water added at once. The mixing must be rapid and thorough, and the mortar, which should be stiff and plastic, should be firmly pressed into the molds with the trowel, without ramming, and struck off level: the molds in each instance, while being charged and manipulated, to be laid directly on glass, slate or some other non-absorbent material. The molding must be completed before incipient setting begins. As soon as the briquettes are hard enough to bear it they should be taken from the molds and be kept covered with a damp cloth until they are immersed. For the sake of uniformity, the briquettes, both of neat cement and those containing sand, should be immersed in water at the end of 24 hours, except in the case of one-day tests.

Ordinary, fresh, clean water, having a temperature between 60 and 70 degrees F., should be used for the water of mixture and immersion of samples.

The proportion of water required varies with the fineness, age, or other conditions of the cement, and the temperature of the air, but is approximately as follows:—

For briquettes of neat cement: Portland, about 25 per cent. natural, about 30 per cent.

For briquettes of 1 part cement, 1 part sand: about 15 per cent. of total weight of sand and cement.

For briquettes of 1 part cement, 3 parts sand: about 12 per cent. of total weight of sand and cement.

American natural cement, 1 part of cement to 1 part of sand.

1 week, 1 day in air, 6 days in water, from 30 pounds to 50 pounds.

1 month (28 days), 1 day in air, 27 days in water, from 50 pounds to 80 pounds.

1 year, 1 day in air, the remainder in water, from 200 pounds to 300 pounds.

American and foreign Portland cements, 1 part of cement to 3 parts of sand:—

1 week, 1 day in air, 6 days in water, from 80 pounds to 125 pounds.

1 month (28 days), 1 day in air, 27 days in water, from 100 pounds to 200 pounds.

1 year, 1 day in air, the remainder in water, from 200 pounds to 350 pounds.

Standards of minimum fineness and tensile strength for Portland cement, as given below, have been adopted in some foreign countries.

In Germany, by Berlin Society of Architects, Society of Manufacturers of Bricks, Lime and Cement, Society of Contractors, and Society of German Cement Makers.

The object is to produce the plasticity of rather stiff plasterer's mortar.

An average of 5 briquettes may be made for each test, only those breaking at the smallest section to be taken. The briquettes should always be put in the testing machine and broken immediately after being taken out of the water, and the temperature of the briquettes and of the testing room should be constant between 60 and 70 degrees F.

The stress should be applied to each briquette at a uniform rate of about 400 pounds per minute, starting each time at 0. With a weak mixture one-half the speed is recommended.

Weight.

The relation of the weight of cement to its tensile strength is an uncertain one. In practical work, if used alone, it is of little value as

---

Standard of 1877.	Fineness, not more than 25 per cent. to be left on sieve of 5,806 meshes per square inch. Tensile strength, 1 part cement, 3 parts sand, 1 day in air, 27 days in water, 113.78 pounds per square inch.
Standard of 1878.	Fineness, not more than 20 per cent. to be left on sieve, as above. Tensile strength, same mixture and time as above, 142.23 pounds per square inch.

In Austria, by Austrian Association of Engineers and Architects.

Standard of 1878.	Fineness, same as German of 1878. Tensile strength, same mixture as above, 7 days, 1 day in air, 6 days in water, 113.78 pounds per square inch. 28 days, 1 day in air, 27 days in water, 170.68 pounds per square inch.

In Austria a standard for the minimum fineness and tensile strength of Roman cement was established and generally accepted, as follows:

Standard of 1878	Fineness, same as Portland. Tensile strength (1 part of cement, 3 parts of sand), for Quick-setting cement (taking 15 minutes or less to set): 7 days, 1 day in air, 6 days in water, 23 pounds per square inch. 28 days, 1 day in air, 27 days in water, 56.9 pounds per square inch. Slow-setting cement (taking more than 15 minutes to set): 7 days, 1 day in air, 6 days in water, 42.6 pounds per square inch. 28 days, 1 day in air, 27 days in water, 85.3 pounds per square inch.

The Roman cements correspond to those classified in this report under the head of natural cements.

Standards have been adopted also in Sweden and Russia.

a test, while in connection with the other tests recommended it is unnecessary, except when the relative bulk of equal weights of cement is desired.

We recommend that the cubic foot be substituted for the bushel as the standard unit, whenever it is thought best to use this test.

Setting.

The rapidity with which a cement sets or loses its plasticity furnishes no indication of its ultimate strength. It simply shows its initial hydraulic activity.

For purposes of nomenclature, the various cements may be divided arbitrarily into two classes, namely: quick-setting, or those that set in less than half an hour; and slow-setting, or those requiring half an hour or more to set. The cement must be adapted to the work required, as no one cement is equally good for all purposes. In submarine work a quick-setting cement is often imperatively demanded, and no other will answer, while for work above the water-line less hydraulic activity will usually be preferred. Each individual case demands special treatment. The slow-setting natural cements should not become warm while setting, but the quick-setting ones may, to a moderate extent, within the degree producing cracks. Cracks in Portland cement indicate too much carbonate of lime, and in the Vicat cements too much lime in the original mixture.

Sampling.

There is no uniformity of practice among engineers as to the sampling of the cement to be tested, some testing every tenth barrel, others every fifth, and others still every barrel delivered. Usually, where cement has a good reputation, and is used in large masses, such as concrete in heavy foundations, or in the backing or hearting of thick walls, the testing of every fifth barrel seems to be sufficient; but in very important work, where the strength of each barrel may in a great measure determine the strength of that portion of the work where it is used, or in the thin walls of sewers, etc., etc., every barrel should be tested, one briquette being made from it.

In selecting cement for experimental purposes, take the samples from the interior of the original packages, at sufficient depth to insure a fair exponent of the quality, and store the same in tightly-closed receptacles impervious to light or dampness until required for manipulation, when each sample of cement should be so thoroughly mixed, by sifting or otherwise, that it shall be uniform in character throughout its mass.

Sieves.

For ascertaining the fineness of cement it will be convenient to use three sieves, viz. :—

No. 50 (2,500 meshes to the square inch), wire to be of No. 35 Stubbs' wire gauge.

No. 74 (5,476 meshes to the square inch), wire to be of No. 37 Stubbs' wire gauge.

No. 100 (10,000 meshes to the square inch), wire to be of No. 40 Stubbs' wire gauge.

The object is to determine by weight the percentage of each sample that is rejected by these sieves, with a view not only of furnishing the means of comparison between tests made of different cements by different observers, but indicating to the manufacturer the capacity of his cement for improvement in a direction always and easily within his reach. As already suggested in another connection, the tests for tensile strength should be applied to the cement as offered in the market, as well as to that portion of it which passes the No. 100 sieve.

For sand, two sieves are recommended, viz. :—

No. 20 (400 meshes to the square inch), wire to be of No. 28 Stubbs' wire gauge.

No. 30 (900 meshes to the square inch), wire to be of No. 31 Stubbs' wire gauge.

Standard Sand.

The question of a standard sand seems one of great importance, for it has been found that sands looking alike and sifted through the same sieves, give results varying within rather wide limits.

The material that seems likely to give the best results is the crushed quartz used in the manufacture of sandpaper. It is a commercial product, made in large quantities and of standard grades, and can be furnished of a fairly uniform quality. It is clean and sharp, and although the present price is somewhat excessive (3 cents per pound), it is believed that it can be furnished in quantity for about $5 per barrel of 300 pounds. As it would be used for tests only, for purposes of comparison with the local sands, and with tests of different cements, not much of it would be required. The price of the German standard sand is about $1.25 per 112 pounds, but the article being washed river sand is probably inferior to crushed quartz. Crushed granite could be furnished at a somewhat less rate than quartz, and crushed trap for about the same as granite, but no satisfactory estimate has been obtained for either of these.

The use of crushed quartz is recommended by your Committee, the degree of fineness to be such that it will all pass a No. 20 sieve and be caught on a No. 30 sieve. Of the regular grade, from 15 to 37 per cent. of crushed quartz, No. 3 passes a No. 30 sieve, and none of it passes a No. 50 sieve. As at present furnished, it would need resifting to bring it to the standard size, but if there were sufficient demand to warrant it, it could undoubtedly be furnished of the size of grain required at little, if any, extra expense.

A bed of uniform, clean sand of the proper size of grain has not been found, and it is believed that to wash, dry and sift any of the available sands would so greatly increase its cost, that the product would not be much cheaper than the crushed quartz, and would be much inferior to it in sharpness and uniform hardness of particles.

Molds.

The molds furnished are usually of iron or brass, the price of the former being $2, and of the latter $3 each. Wooden molds, if well oiled to prevent their absorbing water, answer a good purpose for temporary use, but speedily become unfit for accurate work. A cheap, durable, accurate and non-corrodible mold is much to be desired, but is not yet upon the market. It may be added that your Committee are not in entire accord with respect to the merits of this form of briquette, its principal defect being that the rupture must take place at the neck or smallest section, whether the strain be one of extension only or otherwise. With a briquette of such form that oblique strains would usually produce rupture in oblique directions, the trials taking this character would be rejected, and the accuracy of the results correspondingly increased thereby.

Clips.

In using the clips recommended in the preliminary report, it was found in some instances that the specimens were broken at one of the points where they were held. This was undoubtedly caused by the insufficient surface of the clip, which, forming a blunt point, forced out the material. Where the specimens were sufficiently soft to allow this point to be imbedded, they broke at the smallest section, but when hard enough to resist such imbedding they showed a wedge-shaped fracture at the clips. To remedy this the point should be slightly flattened so as to allow of more metal surface in contact with the briquette. Clips made in this way have been used, and good results obtained.

To adapt the one-inch clips of the Riehlé machine only a slight amount of work is necessary; the ends being rounded will admit the proposed new form of briquette, and yet not prevent the use of the old

one, thus allowing comparative tests of the two forms to be made without changing the clips.

There should be a strengthening rib upon the outside of the clips, to prevent them from bending or breaking when the specimens are very strong.

The clips should be hung on pivots so as to avoid, as much as possible, cross strain upon the briquettes.

Machines.

No special machine has been recommended, as those in common use are of good form for accurate work, if properly used, though in some cases they are needlessly strong and expensive. Machines with spring balances are to be avoided, as more liable to errors than others.

It is by no means certain that there exists any great difference in well-made machines of the standard forms given.

The experiments of the Committee do not seem to justify an expression of preference for any one machine.

Amount of Material.

The amount of material needed for making five briquettes of the standard size recommended is, for the neat cements, about one and two-thirds pounds, and for those with sand, in the proportion of three parts of sand to one of cement, about one and one-quarter pounds of sand and six and two-thirds ounces of cement.

All of which is respectfully submitted.

Q. A. Gillmore,
Chairman,
D. J. Whittemore,
J. Herbert Shedd,
Eliot C. Clarke,
Alfred Noble,
F. O. Norton,
W. W. Maclay,
Leonard F. Beckwith,
Thos. C. McCollom.